DESCRIPTION

Process for Producing Nonwoven Fabric and Nonwoven Fabric

Technical Field

[0001] The present invention relates to a process for production of a nonwoven fabric obtained by laminating continuous filament yarn, and to a nonwoven fabric obtained by laminating continuous filament yarn.

Background Art

[0002] As industrial materials including anti-concrete flaking materials, there are commonly used woven and knitted fabrics made of glass fibers, carbon fibers, aramid fibers, vinylon fibers and the like, as well as various types of Sofu™ (continuous filament nonwoven fabrics). Sofu includes triaxial Sofu laminated in the warp, slant and reverse slant directions, and tetraaxial Sofu laminated in the warp, weft, slant and reverse slant directions.

[0003] Known processes for production of Sofu include processes wherein vinylon fibers, for example, are paralleled in a prescribed direction and the fibers are bonded together with a hot-melt adhesive or emulsion adhesive. Also publicly known are production processes wherein reinforced fibers (glass fibers, carbon fibers, alumina fibers, aramid fibers or the like) coated with a thermoplastic resin are paralleled and fused together (for example, see Patent document 1), and production processes wherein a thermoplastic resin is attached and bonded to the surfaces of reinforced fibers (for example, see Patent document 2). There are also known mesh sheets obtained by weaving or knitting using core-sheath fibers comprising a polyester-based polymer as the core and a polyester-based polymer with a lower

melting point than the core polyester-based polymer as the sheath (for example, see Patent document 3).

[Patent document 1] Japanese Unexamined Patent Publication No. HEI 11-20059

[Patent document 2] WO00/21742

[Patent document 3] Japanese Unexamined Patent Publication No. 2003-301346

Disclosure of the Invention

Problems to be Solved by the Invention

[0004] However, in production processes involving bonding with a hot-melt adhesive or emulsion adhesive after setting of vinylon fibers, cost is increased due to use of the adhesive, while the adhesive also adheres to unwanted sections and creates a poor operating environment for the nonwoven fabric production process.

[0005] In processes employing a thermoplastic resin for fusion of reinforced fibers, because it is difficult to completely cover the reinforced fibers with the thermoplastic resin, the adhesive force is inadequate and consequently the durability is not sufficient particularly for long-term use such as for anti-concrete flaking.

[0006] On the other hand, for mesh sheets obtained by weaving or knitting using a polyester-based polymer with a core-sheath structure, it is not possible to increase the gaps between fibers as with Sofu and they are poorly suitable as anti-concrete flaking materials, while extra labor is required for manufacture of the mesh body, such that the production cost is increased.

[0007] In addition, the aforementioned disclosed examples of Sofu and

mesh sheets all have poor plasticity and flexibility, and their shape following property is therefore inadequate. Because such Sofu and mesh sheet materials are not very universally applicable in the field of industrial materials such as anti-concrete flaking materials, there is a strong demand for their improvement.

[0008] It is therefore an object of the present invention to provide a production process for a nonwoven fabric comprising continuous filaments with excellent plasticity and flexibility, a superior shape following property and also adjustable strength and plasticity to yield properties adaptable to various uses and needs. It is another object of the invention to provide a nonwoven fabric comprising continuous filaments obtained by the aforementioned production process.

Means for Solving the Problems

[0009] In order to achieve these objects, the nonwoven fabric production process of the invention is characterized by comprising a laminating step of bundling a plurality of resin single filaments each having a core-sheath structure with a filamentous core resin surrounded by a sheath resin with a melting point of at least 20°C lower than the core resin, fusing the sheath resin together to form composite yarn, and laminating it in at least the three directions of warp direction, slant direction and reverse slant direction, and a bonding step of heating the laminated composite yarn at a temperature lower than the melting point of the core resin and higher than the melting point of the sheath resin for bonding.

[0010] The composite yarn used in the nonwoven fabric production process of the invention is obtained by fusing the sheath resin, and

therefore it has excellent plasticity and strength while the resin single filaments do not separate, thereby allowing production of a nonwoven fabric with minimal trouble during nonwoven fabric production and excellent plasticity and strength. Furthermore, since the sheath resin of the core-sheath structure has a melting point that is at least 20°C lower than the core resin, when the composite yarn is laminated in different directions and then heated at a temperature below the melting point of the core resin and higher than the melting point of the sheath resin in the nonwoven fabric production process of the invention, only the sheath resin is melted without melting of the core resin, thereby allowing the composite yarn to be bonded together. In other words, it is possible to produce a nonwoven fabric of the invention without using an adhesive such as a hot-melt resin or thermoplastic resin. Furthermore, since the difference in melting points is 20°C or more, the core resin is resistant to melting despite melting of the sheath resin, and the core resin maintains its filamentous shape, thereby allowing deformation of the composite yarn to be prevented during production of the nonwoven fabric. In other words, since it is possible to prevent deformation or cutting of the composite yarn that readily occurs when using resin single filaments without a core-sheath structure, trouble during production is further minimized.

[0011] Furthermore, because the composite yarn is laminated in at least the three directions of warp direction, slant direction and reverse slant direction, a nonwoven fabric with excellent strength can be produced regardless of the directional property.

[0012] The composite yarn in the nonwoven fabric production process

of the invention is composed of 10-500 resin single filaments, and preferably the core resin of the composite yarn forms filamentous island sections with a size of 1-70 dtex (island resin) while the fused sheath resin forms sea sections (sea resin). Because this type of composite yarn is in the form of a fiber-reinforced thermoplastic resin, it has strength and rigidity in the lengthwise (fiber axis) direction, and using such composite yarn can further improve the plasticity and strength of the nonwoven fabric. Moreover, the cross-sectional diameter and number of bundles of the island resin can be adjusted to achieve suitable strength and plasticity, for a further improved shape following property.

[0013] For the nonwoven fabric production process of the invention, the core resin and sheath resin of the resin single filaments in the core-sheath structure are preferably polyolefins. Using a polyolefin as the core resin will result in superior plasticity and workability. If both the core resin and sheath resin are polyolefins, affinity between the core resin and sheath resin is high so that even when the polyolefin of the sheath resin has melted it does not separate from the polyolefin of the core resin, thereby allowing a composite yarn structure to be maintained having the core as reinforcing fiber and the sheath as matrix resin. Furthermore, since polyolefins are non-polar it is possible to produce a nonwoven fabric with resistance to acids and bases and excellent durability.

[0014] The core resin is preferably polypropylene and the sheath resin is preferably polyethylene with a melting point of no higher than 120°C. A nonwoven fabric having this construction exhibits the

properties of composite yarn together with particularly excellent plasticity and flexibility, and a superior shape following property. That is, when conventional Sofu is used to cover folded sections they spring back by the elasticity of the Sofu due to poor plasticity and flexibility, such that it is difficult to cover corners, but the nonwoven fabric of the invention is easily folded and can therefore follow the shape of objects when bonded thereto.

[0015] If the core resin is polypropylene its melting point is relatively high, and therefore separation and decomposition by heat or acids/bases can be prevented. The nonwoven fabric can therefore maintain its shape even with prolonged use. Also, since polypropylene is a thermoplastic resin, it can be recycled and is environmentally friendly.

[0016] Furthermore, since a polyethylene sheath resin has a relatively low melting point it melts readily, and particularly if its melting point is 120°C or below the manufacturing efficiency is drastically improved and energy loss is reduced.

[0017] The nonwoven fabric of the invention is a nonwoven fabric obtained by laminating a composite yarn having 10-500 filamentous island resin filaments with a size of 1-70 dtex situated in a filamentous sea resin (preferably with the filamentous island resin situated along the lengthwise direction of the filamentous sea resin) in at least the three directions of warp direction, slant direction and reverse slant direction, and melting the sea resin to bond together the laminated composite yarn, characterized in that the sea resin has a melting point of at least 20°C below that of the island resin. This type of composite

yarn has excellent plasticity and therefore produces minimal trouble in the production of nonwoven fabrics, while yielding nonwoven fabrics with excellent plasticity and strength.

[0018] The production process for the composite yarn in the nonwoven fabric of the invention may be any of the following.

(1) A process wherein resin single filaments with a core-sheath structure are bundled and stretched at a temperature below the melting point of the core resin and above the melting point of the sheath resin, while melting the sheath resin to fuse the sheath resin together and form a sea resin (matrix), for composite yarn having a sea-island structure with the core resin as the island resin (reinforcing fiber).

(2) A process wherein stretched core-sheath structure filaments are heated in a paralleled state at a temperature higher than the melting point of the sheath and below the melting point of the core, while thermally bonding the sheaths together through a die of prescribed diameter.

(3) A process involving stretching of unstretched filaments having a sea-island structure composed of an island resin and a sea resin with a melting point that is at least 20°C lower than that of the island resin.

In order to obtain a composite yarn with more excellent plasticity and strength, the aforementioned processes (1) and (2) are preferred, with process (1) being especially preferred.

[0019] The composite yarn with the sea-island structure in the nonwoven fabric of the invention preferably employs polyolefins as both the sea resin and the island resin, preferably with polypropylene as the sea resin and polyethylene with a melting point of no higher than

120°C as the island resin.

[0020] The weight ratio of the island resin and sea resin in the composite yarn of the nonwoven fabric of the invention is preferably 20:80-80:20. Such a weight ratio will allow the strength and plasticity to be appropriately adjusted.

Effect of the Invention

[0021] According to the nonwoven fabric production process of the invention, it is possible to produce a nonwoven fabric which is superior in plasticity and shape following property, with adjustable strength and plasticity to adapt to different uses and required characteristics. Nonwoven fabrics obtained by this production process are useful as anti-concrete flaking materials, riverbed protective nets, aquaculturing runoff preventing nets, vermin protection nets, filter casing materials and the like.

Brief Explanation of the Drawings

[0022] Fig. 1 is a plan view showing a nonwoven fabric according to an embodiment.

Fig. 2 is an enlarged perspective view of section P of Fig. 1.

Fig. 3 is a perspective view showing bundled resin single filaments.

Fig. 4 is a perspective view showing a composite yarn for use in a nonwoven fabric of the invention.

Fig. 5 is a plan view showing the positional relationship between the contact surface of the warp yarn 11 and slant yarn 12, and the reverse slant yarn 13 in the nonwoven fabric of Fig. 1.

Fig. 6 is a plan view showing another example of the positional relationship between the contact surface of the warp yarn 11 and slant

yarn 12, and the reverse slant yarn 13 in the nonwoven fabric of the invention.

Fig. 7 is a plan view showing a drum and traverser feeding a warp yarn group and a weft yarn group.

Fig. 8 is a front view showing the drum, traverser and weft yarn feeding mechanism.

Fig. 9 is a plan view showing a nonwoven fabric according to another embodiment.

Explanation of Symbols

[0023] 10,40: Nonwoven fabric, 11: warp yarn, 12: slant yarn, 13: reverse slant yarn, 20a: resin single filament bundle, 20b: composite yarn, 21a: core resin, 21b: island resin, 22a: sheath resin, 22b: sea resin, 23a: resin single filaments, 30: nonwoven fabric production apparatus, 31: drum, 32: rotary axis, 33a,33b: thread guard, 34: traverser, 35: weft yarn feeding mechanism, 36: throughholes, H: contact surface, T1: warp yarn group, T2: weft yarn group, T3: slant yarn group.

Best Mode for Carrying Out the Invention

[0024] Preferred embodiments of the invention will now be explained in detail, with reference to the accompanying drawings. Fig. 1 is a plan view showing a nonwoven fabric according to an embodiment.

[0025] The nonwoven fabric 10 shown in Fig. 1 is composed of a plurality of warp yarns 11 oriented in the warp direction, a plurality of slant yarns 12 oriented at a slant with respect to the warp yarns 11 and a plurality of reverse slant yarns 13 oriented at a slant with respect to the warp yarns 11 and slant yarns 12. The warp yarns 11, slant yarns 12 and reverse slant yarns 13 are all composite yarns, and are identical

except for the different paralleled directions. Also, all of the warp yarns 11, slant yarns 12 and reverse slant yarns 13 are arranged at equal spacings, with the contact surface between the warp yarns 11 and slant yarns 12 positioned on the reverse slant yarns 13.

[0026] Fig. 2 is an enlarged perspective view of a section of crossing between a warp yarn 11, slant yarn 12 and reverse slant yarn 13 (region P of Fig. 1). As shown in Fig. 2, the warp yarns 11, slant yarns 12 and reverse slant yarns 13 of this embodiment have ellipsoid cross-sectional shapes. Here, the warp yarn 11 is bonded to the slant yarn 12 at contact surface H, and the reverse slant yarn 13 is bonded to the slant yarn 12 on the surface opposite the contact surface H. The contact surface H between the warp yarn 11 and slant yarn 12 and the contact surface between the slant yarn 12 and the reverse slant yarn 13 are bonded by melting of the sheath resin.

[0027] Fig. 3 is a perspective view showing a bundle of resin single filaments (hereinafter referred to as "resin single filament bundle"). The resin single filament bundle 20a shown in Fig. 3 is obtained, for example, by bundling resin single filaments in an unstretched state. That is, the resin single filament bundle 20a comprises a plurality of bundled resin single filaments 23a each having a core-sheath structure comprising a core resin 21a and a sheath resin 22a.

[0028] Fig. 4 is a perspective view showing a composite yarn according to the invention. The composite yarn 20b is formed, for example, by stretching the unstretched resin single filament bundle 20a obtained by bundling a plurality of resin single filaments 23a of the core-sheath structure shown in Fig. 3, while melting the sheath resin to

fuse the sheath resin together, thereby creating an approximately ellipsoid cross-sectional shaped sea-island structure.

[0029] In other words, in the composite yarn 20b as shown in Fig. 4, the core resin 21a becomes the island resin 21b while the sheath resin 22a fuses to become the sea resin 22b. As a result, an overall sea-island structure is formed. A composite yarn 20b obtained in this manner is most suitable as the composite yarn for obtaining a nonwoven fabric 10 from the viewpoint of strength and plasticity.

[0030] Figs. 5 and 6 are plan views showing positional relationships between the warp yarn 11 and slant yarn 12 contact surface and the reverse slant yarn 13. In Fig. 5, the warp yarn 11 and slant yarn 12 contact surface is above the reverse slant yarn 13, and the nonwoven fabric 10 shown in Fig. 1 has this positional relationship. In contrast, the warp yarn 11 and slant yarn 12 contact surface in Fig. 6 is not above the reverse slant yarn 13, but rather the warp yarn 11 and slant yarn 12, the warp yarn 11 and reverse slant yarn 13 and the slant yarn 12 and reverse slant yarn 13 are each separately bonded. The nonwoven fabric of the invention may have this type of positional relationship in at least some portions.

[0031] Because the nonwoven fabric 10 has filament bundles laminated in the warp direction, slant direction and reverse slant direction, excellent strength is exhibited regardless of the direction. Moreover, as shown in Fig. 1, the nonwoven fabric 10 also has equally spaced arrangement of the warp yarn 11, slant yarn 12 and reverse slant yarn 13, and therefore an excellent balance is achieved without variation in strength of the nonwoven fabric. In addition, the

crossings of the fiber bundles form regular triangles and thus produce an excellent design for the nonwoven fabric 10.

[0032] However, the spacings between the fiber bundles do not necessarily have to be equal. By adjusting the spacing between the warp yarns 11, the slant yarns 12 or the reverse slant yarns 13, the nonwoven fabric 10 can be imparted with the desired plasticity and strength, and the sizes of the gaps between the fiber bundles can be adjusted as desired. It is thereby possible to confer properties as required for the form and purpose of use.

[0033] Because the nonwoven fabric 10 has excellent strength and shape following properties, it may be suitably used in the field of industrial materials. In particular, because the gaps between fiber bundles can be adjusted, the gaps between the fiber bundles can be increased moderately for use as an anti-concrete flaking material, for example, to exhibit excellent integration with concrete and high anti-concrete flaking performance.

[0034] Furthermore, since a hot-melt adhesive, thermoplastic resin or other adhesive is unnecessary for production of the nonwoven fabric 10, it is possible to eliminate the step of adding a hot-melt adhesive or thermoplastic resin and thus increase the manufacturing speed. Also, since the nonwoven fabric 10 can be bonded by lamination and heating of the warp yarn 11, slant yarn 12 and reverse slant yarn 13, it can be produced in a relatively easy manner. In other words, mass production is facilitated and excellent productivity can be achieved.

[0035] Furthermore, because the composite yarn 20b has a sea-island structure as shown in Fig. 4, the sea resin 22b melts during production

of the nonwoven fabric 10, resulting in fused bonding of the sea resins 22b of adjacent composite yarns 20b. The nonwoven fabric 10 therefore exhibits high strength overall.

[0036] The core resin 21a must have a melting point that is at least 20°C higher than the sheath resin 22a. If the melting point difference is at least 20°C, the core resin will be resistant to melting even when the sheath resin melts, thereby allowing the strength of the core filaments to be maintained while keeping the shape of the composite yarn. A larger difference in melting points is therefore preferred, and even more preferably it is at least 40°C.

[0037] According to this embodiment, the core resin 21a is composed of polypropylene and the sheath resin 22a is composed of polyethylene. If the sheath resin 22a is composed of polyethylene, melting and bonding will be accomplished efficiently during heating because polyethylene is thermoplastic and has a relatively low melting point. If the core resin 21a is composed of polypropylene, the relatively high melting point of the polypropylene will result in excellent thermostability even with prolonged use, while its non-polar nature renders it resistant to separation or decomposition by acids or bases, and thus highly durable. Recycling can be easily accomplished by melting and remolding after use. Thus, industrial waste is avoided and the process is safe and environmentally friendly.

[0038] When the structure described above is produced using polypropylene and polyethylene, the plasticity is uniquely excellent and folding can occur easily even if the gaps between composite yarns are narrowed or the number of resin single filaments with the core-sheath

structure is amplified to increase the strength of the nonwoven fabric. Thus, a nonwoven fabric having such a structure can achieve close bonding onto articles even when used to cover folded or curved sections.

[0039] The polyethylene used for the invention is preferably low-density polyethylene, and more preferably it has a melting point of no higher than 120°C. Low-density polyethylene has a low melting point and therefore allows bonding at low temperature, thereby drastically improving the manufacturing efficiency.

[0040] The fineness of the polypropylene used as the island resin 21b is preferably 1-70 dtex and more preferably 2-50 dtex. A size of no greater than 30 dtex is especially preferred if plasticity is desired. If the fineness is less than 1 dtex the island resin 21b will be too thin, thereby making it difficult to retain its shape and tending to impair the physical properties after heat bonding. On the other hand, a fineness of greater than 70 dtex will result in excessively thick resin single filaments 23a, potentially impairing the plasticity and flexibility.

[0041] The composite yarn may be produced by bundling a plurality of the resin single filaments 23a while stretching them, and preferably the number of bundled filaments is 10-500. With less than 10 filaments, the resin single filaments 23a will be too thick and may impair the spinning property, while more than 500 filaments increases the spinning nozzle density and results in thinner resin single filaments 23a, thereby potentially impairing the spinning property and stretchability. The number of filaments is more preferably 100-300.

[0042] The fineness of the composite yarn 20b is preferably 100-5000

dtex. At less than 100 dtex it will be difficult to achieve the desired physical properties, and at greater than 5000 dtex the plasticity and shape following property may be impaired. The size is more preferably 500-3000 dtex.

[0043] The nonwoven fabric of the invention preferably comprises the island resin 21b and sea resin 22b in a weight ratio of 20:80-80:20. If the weight ratio of the island resin 21b and sea resin 22b is a proportion of less than 20% it may be difficult to achieve the desired physical properties, and if the weight ratio of the island resin 21b and sea resin 22b is a proportion of greater than 80%, the heat bonding strength may be reduced. The weight ratio is more preferably 40:60-70:30.

[0044] The nonwoven fabric 10 may be fabricated using a nonwoven fabric production apparatus. Fig. 7 is a plan view of a production apparatus for production of a nonwoven fabric 10, and Fig. 8 is a front view of the same.

[0045] The nonwoven fabric production apparatus 30 shown in Fig. 7 and Fig. 8 is provided with a circular cross-section shaped drum 31, a traverse 34 and a weft yarn feeding mechanism 35. The drum 31 rotates in the counter-clockwise direction of the drawing, centered around a rotating axis 32 parallel to the y-direction. The traverser 34 reciprocates along the side face of the drum 31 in the y-direction, forming a slant yarn group T3 on the warp yarn group T1 fed to the drum 31. The weft yarn feeding mechanism 35 feeds the weft yarn group T2 to the traverser 34 for formation of the slant yarn group T3.

[0046] For production of a nonwoven fabric 10 using the nonwoven fabric production apparatus 30, first the warp yarn group T1 consisting

of a plurality of parallel warp yarns 11 in the warp direction (the X-direction in the drawing) is supplied along the side face of the cylindrical drum 31 so as to wrap around the circumferential direction. The drum 31 is supported by a rotatable base (not shown) with the axis 32 as the center, and it rotates at a fixed speed with respect to the base. There are provided thread guards 33a around the perimeter of one edge and thread guards 33b around the perimeter of the another edge of the drum 31, protruding vertically from the side of the cylinder, arranged in order to equally segment the perimeter. The traverser 34 is provided in an arc shape along the side face of the drum 31, and it is supported in a reciprocally movable manner in the Y-direction along the side face of the drum 31. The traverser 34 has throughholes 36 through which the weft yarn group T2 fed from the weft yarn feeding mechanism 35 passes. The weft yarn group T2 is fed from the weft yarn feeding mechanism 35 through the throughholes 36 to the drum 31, being alternately hooked between the thread guards 33a and thread guards 33b as it reciprocates on both edges of the drum 31, so as to be stretched as a plurality of slant yarns 12 and reverse slant yarns 13 arranged as a slant yarn group T3 on the warp yarn group T1 fed to the side face of the drum 31.

[0047] Thus, a nonwoven fabric 10 is formed by the slant yarn group T3 stretched slanting across the warp yarn group T1. The reciprocal movement pitch of the traverser 34 is controlled to the prescribed ratio with respect to the rotation pitch of the drum 31. The ratio of the reciprocal movement pitch of the traverser 34 and the rotation pitch of the drum 31 may also be directly controlled by mechanical

interlocking, or it may be indirectly controlled by a servo motor.

[0048] Stronger nonwoven fabrics are commonly demanded in a variety of industrial material fields. For such cases, the density of the Sofu may be increased as mentioned above for higher strength. Specifically, by increasing the number of warp yarns 11 of the warp yarn group T1 having the plurality of warp yarns 11 arranged in the warp direction (the X-direction in the drawing), or narrowing the spacing between the thread guards 33a and 33b formed around the perimeter of the edge of the drum 31, it is possible to provide a high-density nonwoven fabric.

[0049] In the nonwoven fabric production process of the invention, the composite yarns paralleled in the warp direction, slant direction and reverse slant direction are bonded by heating. The heating temperature is below the melting point of the core resin and above the melting point of the sheath resin. Heat treatment in this temperature range will allow melting and bonding of only the sheath resin without melting of the core resin in the core-sheath structure, thereby improving the strength of the nonwoven fabric as a whole. The heating for melting of the sheath resin is preferably contact heating with a heating roller or the like.

[0050] The heat treatment is preferably combined with pressure treatment by cylinder pressurization, air pressurization or dead weight pressurization. Pressure treatment can increase the area of contact of the composite yarns, thereby increasing the contact surface bonding strength while allowing adjustment of the nonwoven fabric thickness.

[0051] The nonwoven fabric of the invention is more preferably

subjected to pressurization in a heated state. Although the sea resin of each composite yarn is melted by heating and bonds with the sea resin of other composite yarns, pressurization in a heated state will crush the composite yarns and further increase the contact surface between the composite yarns and other composite yarns. Thus, pressurization simultaneously with heating can exhibit firmer bonding strength. If pressurized contact is accomplished with the aforementioned drum 31, it will be possible to carry out heated pressure treatment in a single pass, thereby improving the operating efficiency.

[0052] An embodiment of a nonwoven fabric production process according to the invention was explained above, but the invention is not necessarily limited to this embodiment and may incorporate various modifications.

[0053] For example, after forming the composite yarn 20b from the resin single filament bundle 23a, crimping or false twisting techniques may be employed to impart plasticity to the composite yarn. Employing crimping or false twisting techniques can improve the plasticity of the filaments and enhance the workability of the nonwoven fabric.

[0054] The nonwoven fabric 10 according to this embodiment of the invention is triaxial Sofu having composite yarns laminated in the warp direction, slant direction and reverse slant direction. Here, the cross angle between the warp yarn 11 and the slant yarn 12 or reverse slant yarn 13 is preferably 60±10°.

[0055] The composite yarn may also be added in the weft direction of the triaxial Sofu. That is, the composite yarn may be laminated in the

warp direction, weft direction, slant direction and reverse slant direction to obtain tetraaxial Sofu. In this case, the weft yarn is arranged orthogonal to the warp direction. For tetraaxial Sofu, the cross angle between the warp yarn or weft yarn and the slant yarn or reverse slant yarn is preferably 45±10°. Tetraaxial Sofu exhibits excellent strength and exhibits high strength even when twisted.

[0056] For this embodiment, polypropylene was used as the core resin 21a and polyethylene was used as the sheath resin 22a, but different resins may be used as desired depending on the purpose of use and the required properties. Specifically, there may be mentioned polyethylene terephthalate or polyamide (nylon) as the core resin 21a, and a lower melting point resin or copolymer resin as the sheath resin 22a. In particular, when the nonwoven fabric of the invention is to be used as a reinforcing material for cement, the core resin 21a and sheath resin 22a are preferably alkali-resistant thermoplastic resins, and polyolefins are most preferably used. Using a polyolefin as the core resin 21a will result in a superior shape following property and workability. When both the core resin 21a and sheath resin 22a are polyolefins the core resin 21a and sheath resin 22a will have excellent affinity, such that even when the polyolefin of the sheath resin 22a melts it will not separate from the polyolefin of the core resin 21a, thereby allowing the core-sheath structure to be maintained. Furthermore, since polyolefins are non-polar it is possible to produce a nonwoven fabric with resistance to acids and bases and excellent durability.

[0057] Fig. 9 is a plan view showing a nonwoven fabric 40 according

to another embodiment. The nonwoven fabric 40 is composed of a plurality of warp yarns 11 oriented in the warp direction, a plurality of slant yarns 12 oriented at a slant with respect to the warp yarns 11 and a plurality of reverse slant yarns 13 oriented at a slant with respect to the warp yarns 11 and slant yarns 12. The warp yarns 11 in this case are alternately bonded on one or the opposite contact surface between each of the slant yarns 12 and the reverse slant yarns 13.

[0058] The nonwoven fabric 40 having this construction exhibits particularly excellent strength, and exhibits high strength even when twisted. When used as an anti-concrete flaking material it exhibits strength regardless of the shape of the concrete, and it is therefore particularly durable and useful.

[0059] As the production process for the nonwoven fabric 40, the warp yarns 11 are first paralleled and bonded on only one of the contact surfaces between the slant yarns 12 and reverse slant yarns 13, and then the warp yarns 11 are paralleled and bonded on the opposite side.

Example

[0060] <Production of composite yarn>

Isotactic polypropylene with MFR=20 (g/min) was used as the thermoplastic resin for the core resin, and low-density polyethylene resin with MI(190°C)=20 (g/min) was used as the sheath resin. Spinning was performed using an established type of composite spinning apparatus and a core-sheath composite spinning nozzle (150H). After bundling 150 of the obtained resin single filaments, they were passed through a directly coupled stretching apparatus and subjected to roller stretching to a total stretch factor of 14 under

saturated water vapor pressure at an absolute pressure of 4.2 kPa (145°C), and immediately passed through a molding die with a prescribed shape, to obtain an approximately ellipsoid composite yarn having polypropylene fibers (melting point: 165°C) as the island resin bonded to low-density polyethylene (melting point: 113°C) as the sea resin (weight ratio of island resin and sea resin = 55:45).

The obtained composite yarn had a size of 2200 dtex, and the single filaments of the island resin had a size of 33.6 μm and a strength of 6.0 cN/dtex.

[0061] <Production of nonwoven fabric A>

The obtained composite yarn was used as warp yarn and weft yarn for lamination of warp yarn, slant yarn and reverse slant yarn at a pitch of 9 mm using the production apparatus illustrated in Fig. 7 and Fig. 8. Here, the warp yarn was laid alternately as the top and bottom layer, and the slant yarn and reverse slant yarn were laminated as the interlayer. Next, contact heating was performed with a hot roller at a surface temperature of 150°C, for melting of the sea resin of the composite yarn and bonding of the composite yarn in each layer to obtain a nonwoven fabric A.

[0062] (Comparative Example)

<Production of nonwoven fabric B>

Vinylon fibers with a yarn count of 2000 dtex (750 filaments) were used for the warp yarn, slant yarn and reverse slant yarn, and were laminated at the same pitch as in the Example. Next, these were impregnated with an acrylic-based adhesive and contact heated with a hot roller at a surface temperature of 150°C to obtain nonwoven fabric

B having an adhesive coverage of 20 wt% with respect to the vinylon fiber yarn.

[0063] <Test Example 1>

A test was conducted for the shape following property of nonwoven fabrics A and B with folding. The nonwoven fabric A of the Example was easily foldable and maintained its folded shape, but the nonwoven fabric B of the comparative example was difficult to fold and exhibited strong rebound back to its original shape and therefore did not readily maintain its folded shape.

[0064] <Test Example 2>

The tensile strength was measured according to JIS R3420, General Test Method for Glass Fibers, 7.4(a) Test Method for Fabric Tensile Strength. Upon measuring a 25 mm-wide test piece for tensile strength in the warp yarn direction (warp direction) and a 50 mm-wide test piece for tensile strength in the direction orthogonal to the warp yarn direction (weft direction), nonwoven fabric A of the Example exhibited strength of 370 N/25 mm in the warp direction and 37 N/50 mm in the weft direction, while nonwoven fabric B of the comparative example exhibited strength of 480 N/25 mm in the warp direction and 23 N/50 mm in the weft direction.

[0065] Presumably, the tensile strength in the warp direction depends on the material of the warp yarn, while the tensile strength in the weft direction depends on the difference in bonding force between the yarns. Thus, although the nonwoven fabric A of the Example had inferior strength of material compared to the nonwoven fabric B of the comparative example, it had superior strength in terms of bonding

force. In other words, the nonwoven fabric A of the Example had firm bonding between the composite yarns, and therefore had excellent bonding force and improved strength particularly in the weft direction, as well as an excellent shape following property.

Industrial Applicability

[0066] The nonwoven fabric of the invention exhibits excellent plasticity and flexibility and a superior shape following property while also allowing adjustable strength and plasticity to adapt to various purposes and required properties, and therefore it can be applied as an industrial material such as an anti-concrete flaking material.